Space Weather Technical Forecast

Issued on Wednesday, 21 December 2022 at 00:43 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance of M-class flares and G1/Minor Geomagnetic Storms.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate, with an M1.1 flare peaking at 20/1408 UTC from AR3169, which has produced the majority of activity. There have also been frequent C-class flares, including a C8.3 flare at 20/0852 UTC from AR3170. There are seven sunspots on the disc. AR3169 is an elongated group with a series of relatively small leader spots, but no penumbra now on the trailer spots. There is some magnetic complexity, especially due to its proximity to the smaller following region AR3171, which also has some magnetic complexity. The split between these two regions is difficult to determine. AR3170 in the southeast has also been active during the period, but is now starting to fade. The largest region, AR3163, has a large leader spot with nearby reverse polarity spot emergence, but it remains inactive so far. The other regions are generally smaller and stable. There are no Earth-directed CMEs expected, with a couple of recent centre disc eruptions likely to have been reabsorbed. Further weak CME effects cannot be completely ruled out, however.

Solar Wind / Geomagnetic Activity: Solar winds have been indicative of one or perhaps two weak transient features passing Earth, likely due to glances from a CME, potentially coupled with a weak enhancement from CH54/-. Solar wind speeds remained at background levels, around 340-400 km/s. Density started below average, but rose to mostly average or above average with a peak of 15ppcc. The total IMF, Bt, was mostly Moderate peaking at 15nT around 20/0745 UTC, but with a slight drop between 20/1300-1500 UTC. The Bz was mostly northward directed up to +13 nT, before showing a clear rotation after 20/1400 UTC to become southward directed up to -9 nT, before becoming more variable after 20/2115 UTC. The phi angle was mainly negative (towards the Sun), but with some variations. Geomagnetic activity was Quiet to Unsettled (Kp 1-3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 remained at Background levels. High energy electron flux (greater than 2 MeV), as observed by GOES16, was at Background levels. The associated 24-hour fluence was on a steady trend well below Active (1e8 integrated pfu). Observed fluence at 21/0001 UTC was 1.37e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Low to Moderate, with occasional C-flares and an ongoing chance of isolated M-flares. The most likely source is either AR3163 in the southwest, or AR3169 and AR3171 in the northeast. These also bring a very slight chance of X-class flares.

Solar Wind / Geomagnetic Activity: There are no Earth-directed CMEs expected. Solar winds are forecast to become elevated later on Day 1 or early Day 2 (21-22 Dec) due to the arrival of the High Speed Stream (HSS) of CH55/+. Ongoing fast winds are then expected with a

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succession of coronal holes moving from CH55/+ to CH56/+. Wind speeds are likely to remain at slightly elevated or elevated levels for the rest of this period.
Quiet to Unsettled geomagnetic activity at first, is expected to become Unsettled to Active later on Day 1 or early Day 2, with a chance of isolated G1/Minor Storm intervals. This chance decreases a little into Day 3 (23 Dec), before increasing slightly on Day 4 (24 Dec) as CH56 is likely to become geoeffective.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels throughout, although there is slight chance of this reaching the S1/Minor Storm level should any notable flares occur. High energy (greater than 2 MeV) electron flux as observed by GOES-16 is currently at background levels. An increase is possible later in the period due to expected fast winds arriving on Days 1 or 2 (21-22 Dec). The associated 24 hour electron fluence is forecast to remain below the Active (1e8 integrated pfu) threshold, perhaps with a slight rise towards the end of the period.

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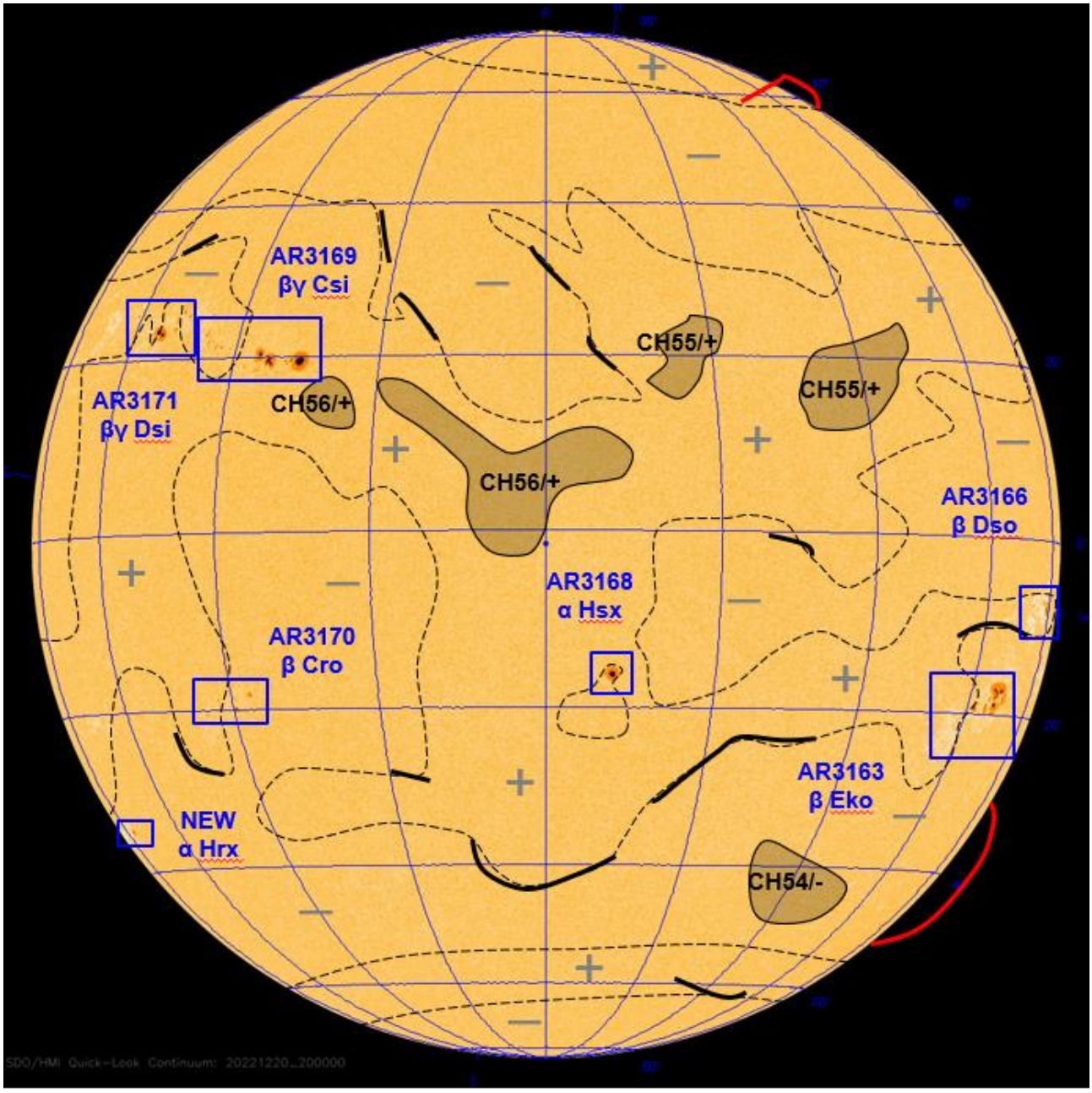
Figure 1. Solar Analysis Valid 20/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are no Earth-directed CMEs expected, but weak CME effects cannot be completely ruled out with a couple of recent centre disc eruptions, although these are most likely to have been reabsorbed.

Solar winds are forecast to become elevated later on Day 1 or early Day 2 (21-22 Dec) due to the arrival of the High Speed Stream (HSS) of CH55/+. This is in agreement with MOSWOC Enlil and the 27-day persistence model. Confidence is starting to increase in the strength and timing of this onset, however, as STEREO-A data is has shown a rotation to a positive phi angle with a gradual increase in density and a slight increase in wind speeds. Ongoing fast winds are then expected with a succession of coronal holes moving from CH55/+ to CH56/+. Whilst there may be slight wind speed decreases in between the main HSS of each coronal hole, wind speeds are likely to remain at slightly elevated or elevated levels for the rest of this period.

Quiet geomagnetic activity at first, is expected to become Unsettled to Active later on Day 1 or early Day 2, with a chance of isolated G1/Minor Storm intervals. This chance decreases a little into Day 3 (23 Dec), before increasing slightly on Day 4 (24 Dec) as CH56 is likely to become geoeffective.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	30	30	20	30
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
*	*	*	*	*	*	*

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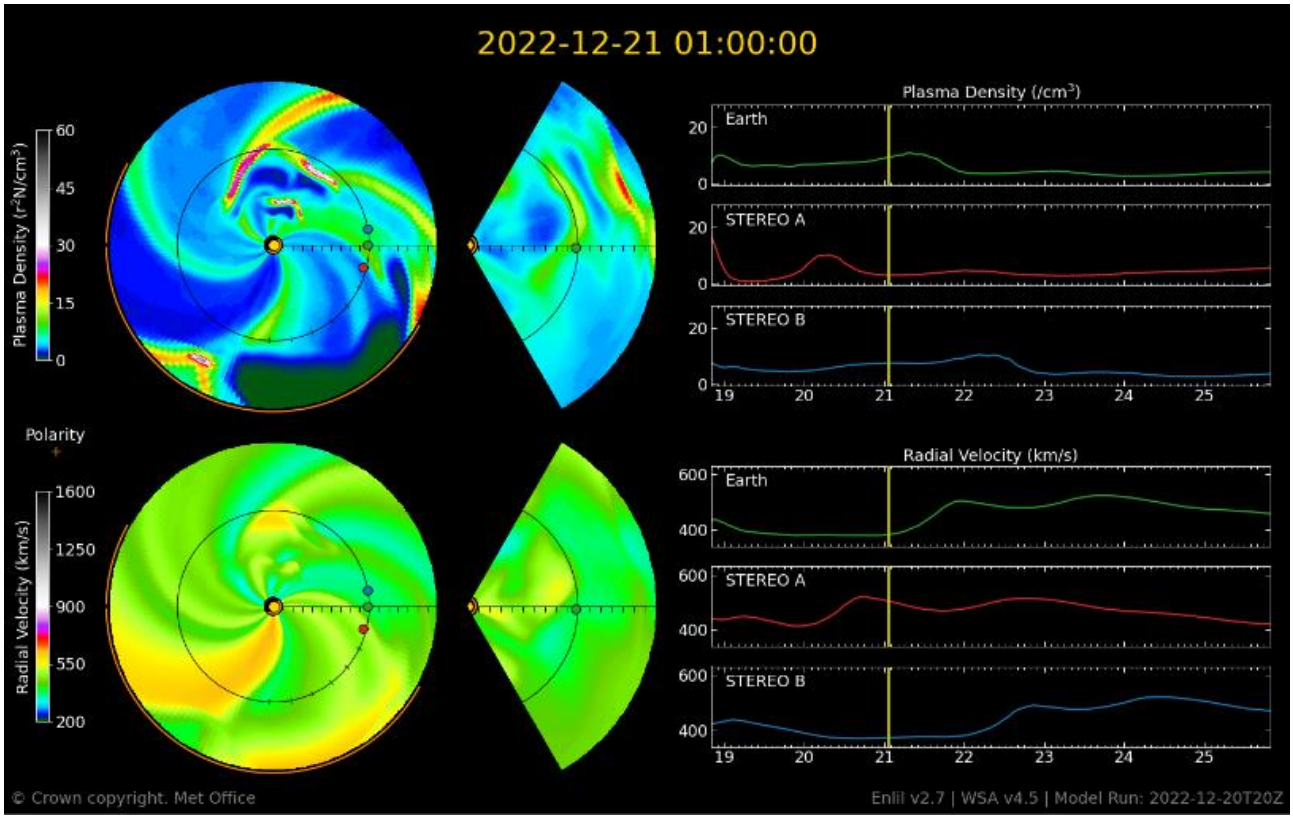
Figure 2: MOSWOC Enlil showing an increase in wind speeds through Days 1 and 2 (21-22 Dec), which seems like good guidance.



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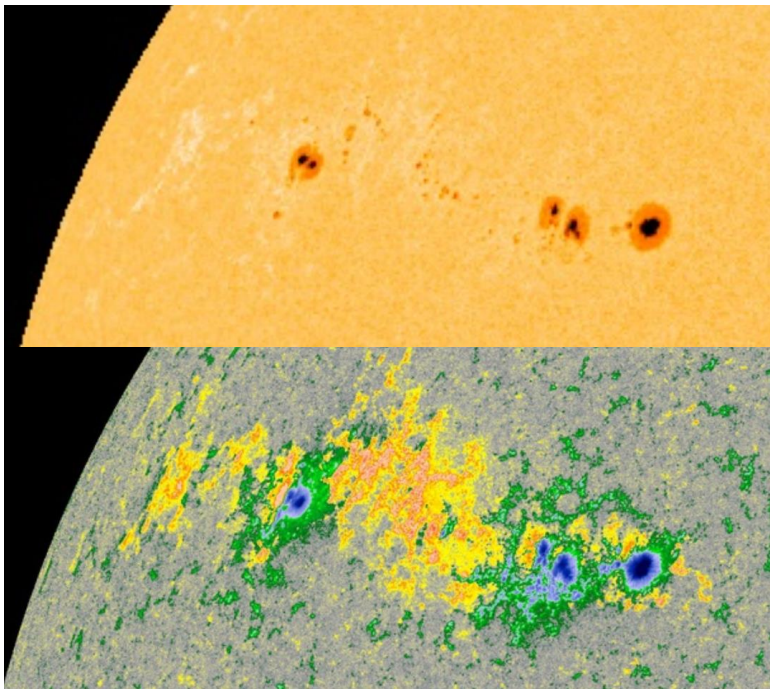
Radio Blackouts - X-Ray Flares:

There are seven sunspot regions on the visible disc, with activity forecast to be Low to Moderate. There is a chance of M-flares, with a very slight chance of X-class flares.

AR3169 (Csi/Beta-Gamma) is currently the most active region on the disc, as an elongated group consisting of a number of mature leader spots but with no penumbra on the trailing spots. It has some magnetic complexity, but this is complicated by its proximity to AR3171 (Dsi/Beta-gamma), which also has some magnetic complexity. The split between these two regions is difficult to determine, however. The largest region on the disc is AR3163 (Eko/Beta). This region is approaching the southwest limb, but has seen development of its leading spot with a reverse polarity spot only just behind the large leading spot. The other regions are generally smaller and simpler, however far-side products suggest further regions are likely to rotate onto the disc though the period. As such, although some regions are due to rotate off in this period, with others likely to rotate on, the flare risk has been kept flat throughout.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	40	40	40	40
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: SDO intensitygram and magnetogram of AR3169 (leading) and AR3171 (following) in the northeast. It is difficult to determine the separation between these areas, and their proximity increases the magnetic complexity.



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Solar Radiation Storms - (High Energy Protons):
The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is expected to remain at background levels. There is a slight chance of an enhancement however, with a number of notable sunspots on the disc. This gives a risk of reaching the S1 Minor Radiation storm level.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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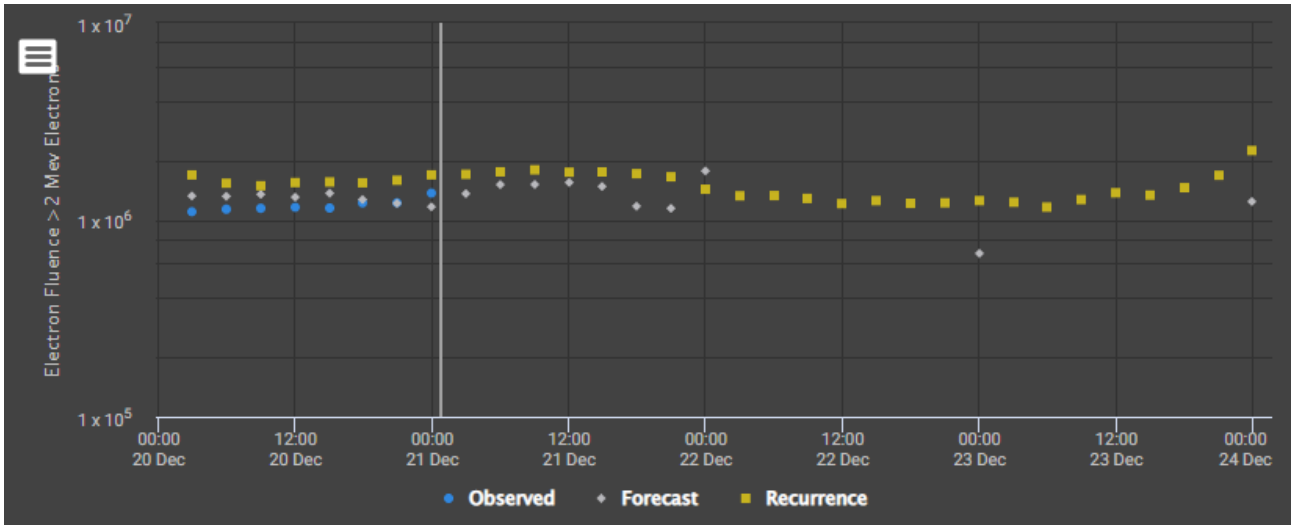
High Energy Electrons Event (≥ 2MeV):
High energy (greater than 2 MeV) electron flux as observed by GOES-16 is currently at background levels. Fast wind arrival either later on Day 1 or early on Day 2 (21-22 Dec) has the potential to result in increased counts later in the period, most likely rising to Moderate, with a chance of a diurnal peak of High on Days 3 and 4 (23-24 Dec). Some uncertainty is introduced by the fact that fast winds are likely to be ongoing for several days, so confidence in the timing and magnitude of any rise is only moderate at best.

The associated 24 hour electron fluence is forecast to remain below the Active (1e8 integrated pfu) threshold, as indicated by REFM, which is currently giving good guidance. On the previous rotation which was similar in terms of coronal holes, the fluence rose on the equivalent of Day 4 but didn't quite reach Active for several more days. As such, fluence may rise later in the period, however this is low confidence and it is more likely fluence will stay below Active until next week.

GEO Electron Environment	Level ($cm^{-2}\ sr^{-1}\ day^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	1	5	10
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 4: MOSWOC REFM showing a below Active forecast for the next 3 days, which seems like reasonable guidance.



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